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How to retrieve nutrients from organic wastes

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A Greener Agriculture for a Bluer Baltic Sea
- Visions for nutrient management
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Outline

- Nutrient recovery potential from organic wastes
- Challenges
- Nutrient recovery from
  - Waste water treatment (process water, sewage sludge, sewage sludge ash)
  - Urine
  - Manure
  - Meat and bone meal
- Summary and recommendations

Recovery potential

Estimation of the potential amounts of nutrients in selected organic waste materials in the EU (1000t/year) (Werner, 2008)			
	N	P	K
Manure	6700	1583	6534
Sewage sludge	330	250	
Animal meals	120	155	
Bio-/green waste	216	47	149
Residues from gelatine production	1.4	0.7	
Residues from potato starch production	18.8	2.9	37.5
Fermentation filter cakes	3.6	1.6	
Molasses production (vinasse)	37.4	0.9	58.0
Defecation lime sugar industry	18.7	27.4	

Challenges

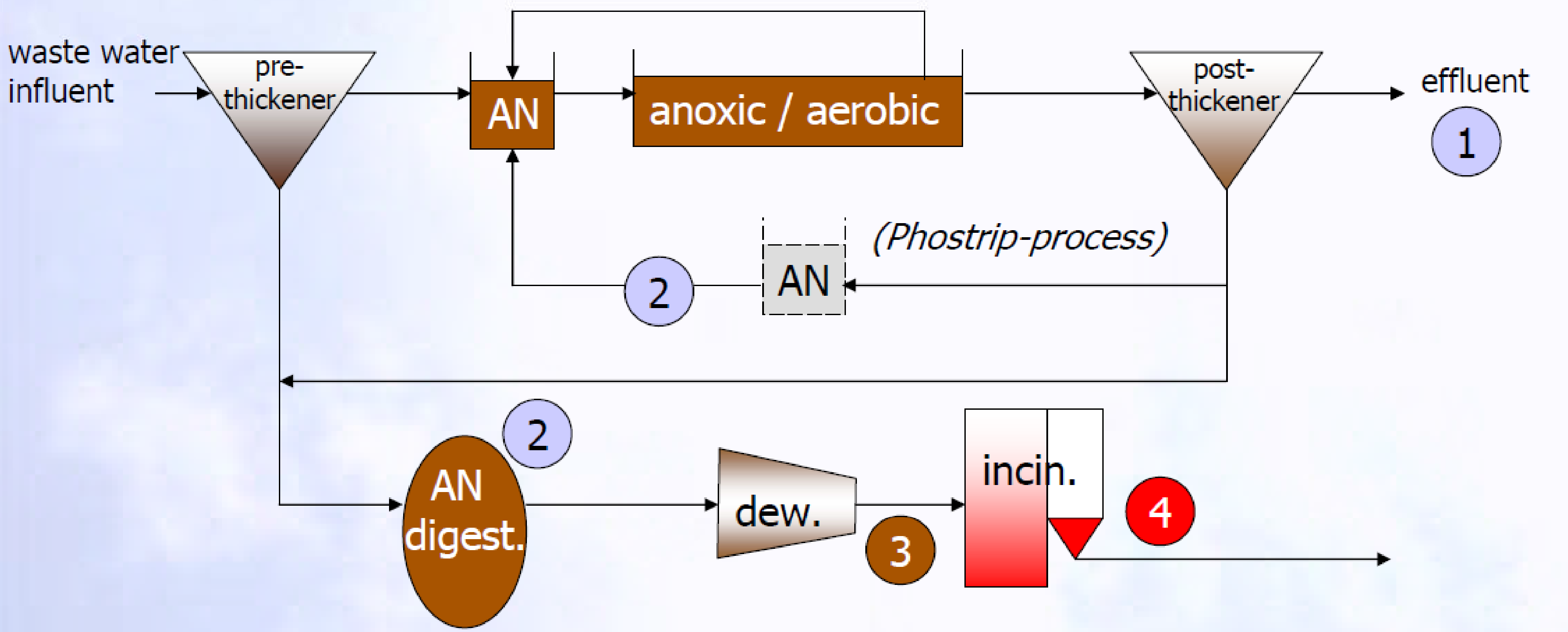
- Organic waste materials may contain:
  - Heavy metals
  - Organic pollutants
  - Pharmaceuticals
  - Pathogens
- Chemical and physical composition
  - Dustiness of raw material
  - Reactivity problems in the wet chemical processes
- Important: stability of chemical quality
- Possible solution: designing new process to produce NPK – or PK - fertilisers from recycled materials
- Finding a suitable market to distribute the product
  - Agronomic efficiency
  - Financial viable and environmentally safe

Technologies for nutrient recycling

Nutrient-recovery from waste water, sewage sludge and sewage sludge ashes

http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2010/07/sewage-sludge.jpg

Possible locations for P-recovery at a waste water treatment plant



1 effluent of WWTP (main stream)

2 process water / sludge liquor (side stream)

3 dewatered sewage sludge

4 sewage sludge ash

(Adam, 2009)

Technologies for P Recycling

Watery phase: waste water (treated) or process water (e.g. sludge liquor)	
Precipitation	• Process Berliner Wasserbetriebe/Air Prex (Heinzmann, 2008) • Prisa process (Pinnekamp and Montag, 2007)
Crystallization	• DHV-Crystalactor® (Giesen and De Boer, 2003) • The OSTARA PEARL™ (Esemag, 2006)
Dewatered or dried sludge	
Wet chemical	• Seaborne /Gifhorn process (Versterager, 2003; Müller, 2005)
Crystallization	• CSH-process Darmstadt (Petzet, 2009)
Thermal	• Mephrec process (Scheidig et al., 2009)
Sewage sludge ash	
Wet chemical	• Sephos process (Cornel and Schaum, 2005) • PASH process (Montag et al., 2005; Pinnekamp et al., 2007)
Thermal	• BAM/AshDec process (Adam, 2009; Herrmann, 2009) • Electro thermal P (Cornel, 2002; Korving and Schipper (2009)

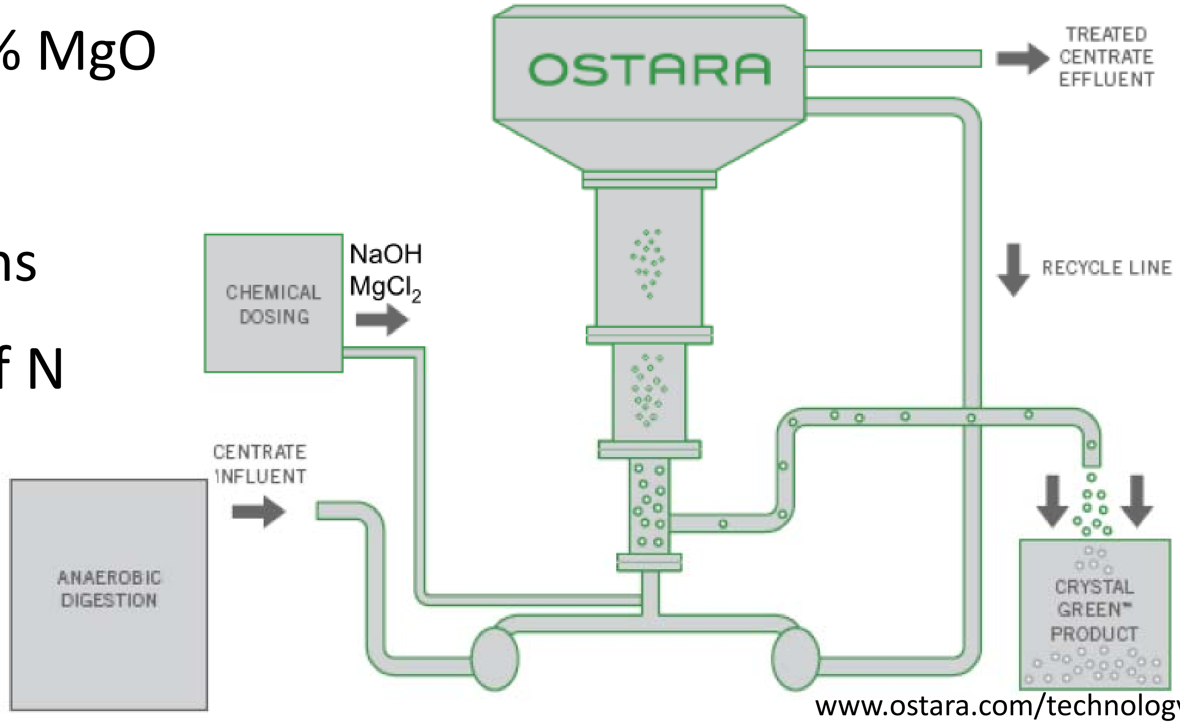
(Adam, 2009)

Watery phase - crystallization

OSTARA PEARL™ Process

- Recovering struvite $(NH_4)Mg(PO_4)*6H_2O)$
- Crystal Green® already sold as "slow release fertiliser"
  - 5% N + 28% P + 15% MgO
  - Inorganic
  - Free from pathogens
- > 85% of P and 40% of N can be recovered

http://www.scientificamerican.com/media/inline/sewages-cash-crop_1.jpg



www.ostara.com/technology

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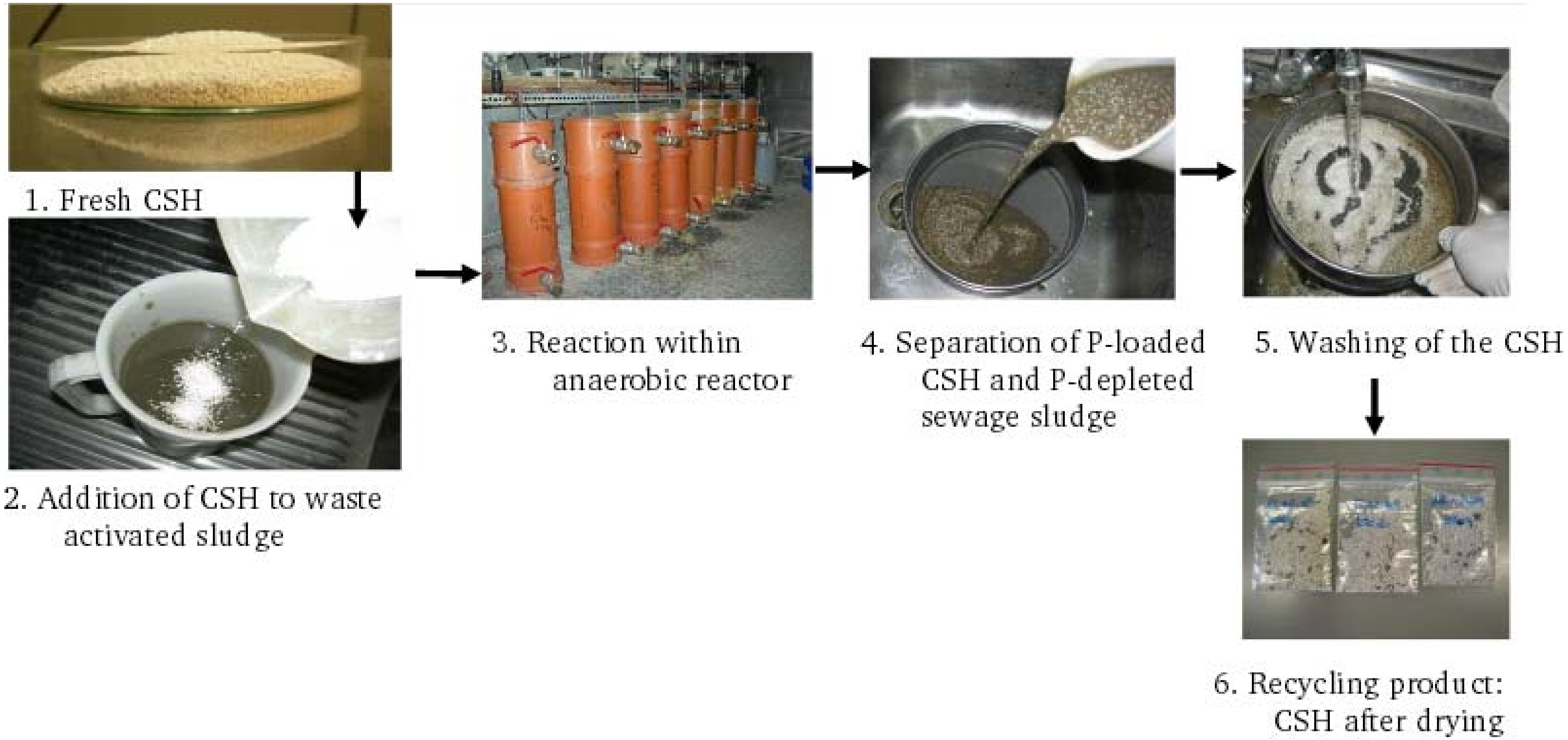
Sewage sludge - crystallization

- P-recovery from Bio-P sludges using calcium-silicate-hydrate (CSH) pellets (Petzet & Cornel 2009)
- Pellets are directly fed into the anaerobic reactor for sludge stabilisation
- P is directly ("in-situ") taken up by the CSH pellets
- Crystallisation of Ca-P is triggered
- P-loaded pellets are removed from the sludge and reused in the fertiliser industry

Sewage sludge - crystallization

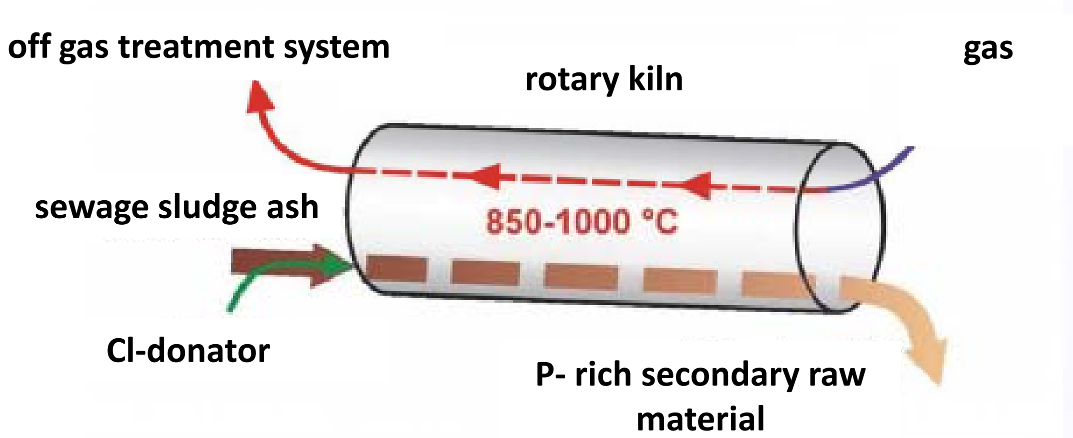


(Petzet & Cornel 2009)

- P-recovery approx. 30% of P contained in wastewater
- Costs: approx. 5€/kg P

Sewage sludge ash – thermo-chemical

- Raw sewage sludge ash
  - P-forms: $AlPO_4$ and $Ca_3(PO_2)_2$ [whitlockite]
  - Free from organic pollutants
  - High heavy metal concentrations
- Thermo-chemically treated sewage sludge ash
  - Significant reduction (< 90%) of Cd, Cu, Pb, and Zn



(Adam, 2008)

Sewage sludge ash – thermal

- Reformation of P-forms:
  - $Ca_5(PO_4)_3Cl$ [Chlorapatite] ⎫
  - $Ca_4Mg_5(PO_4)_6$ [Stanfieldite] ⎭ $MgCl_2$
  - $Ca_5(PO_4)_3Cl$ [Chlorapatite] } $CaCl_2$

- $MgCl_2$ Cl-donor: fertilisation performance of ashes close to SSP
- $CaCl_2$ Cl-donor: lower yield and P-uptake $\rightarrow$ post processing
  - Addition of a fully digested P fertiliser (i.e TSP)
  - Partial digestion e.g. with H_3PO_4 or H_2SO_4
- Costs: approx 2.3€/kg P

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Nutrient-recovery from urine

http://media.treehugger.com/assets/images/2011/10/nomix-toilet-photo-001.jpg

Fertiliser products from human urine

- **Problem:** risk of contamination with pharmaceuticals/synthetic estrogens
- Solution:
  - Struvite precipitation by adding MgO or $MgCl_2$ at pH ≤ 9
  - P recovery rates: 90-98%
- Final product:
  - Low in heavy metals and micro-pollutants
  - Represents a valuable market fertiliser
  - Fertilising effect comparable to commercial fertilisers (Ganrot, 2009)

Distribution of N and P in human excretions (Vinneras, 2004; quoted after Kroiss et al., 2011)

	Urine g/(PE*a)	Faeces g/ (PE*a)	**Urine (%)**	Faeces (%)
N	**4000**	550	**88**	12
P	**365**	183	**67**	33

Nutrient-recovery from manure

http://www.tierschutzbund.de/information/hintergrund/landwirtschaft/schweine/schweinemast-anlage-allstedt.html

Slurry separation

- Slurry: improper N/P-balance which does not match plant need
- Solution: Separation of slurry
  - Sedimentation
  - Centrifugation
  - Drainage
  - Pressurised filtration
- Liquid fraction: high N:P ratio → on farm use as N-source
- Solid fraction: narrow N:P ratio → transport to farms with low livestock density
  - Substitution for mineral fertiliser P
- Problems:
  - Change of plant nutrient/heavy metal ratio in the biomass (depending on the separation process)
  - Fate of pathogens?

Nutrient-recovery from meat and bone meal

http://www.ave.at/ave_at/images/315200390213632229_49994646948909218_0p6MtR0E.jpg

Thermal digestion of meat and bone meal

- Average nutrient concentration MBM: 8% N, 5% P, 1% K and 10% Ca (Chen et al., 2011)
- Bone fraction: apatite; meat fraction: organic P
- Slow release fertiliser on acid soils (< pH 5.5)
- Comparable to rock phosphate
- MBM-ash: also poor agricultural performance
- Digestion of MBM-ash in liquid converter slag (1600 °C) increases :
  - P solubility (e.g. Citric acid from 53% up 87%)
  - DMY and P-uptake

→ comparable to fully digested P fertiliser

- Technique also applicable to SSA


(Rex, 2009)

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Summary/conclusion

- Nutrient-recycling with focus on P is essential
- Different secondary raw materials can be used for recovery
  - Process water
  - Sewage sludge and sewage sludge ash
  - Manure
  - Urine
  - Meat and bone meal
- Different techniques can be used to recover nutrients
  - Precipitation
  - Crystallisation
  - Separation
  - Thermal treatment
  - Wet chemical process

Recommendations

Political:

- Formulation of threshold values for relevant heavy metals in the European fertiliser ordinance
- Mandatory mixing of recycling P with rock phosphate P
- Imposing charges/taxes on Cd and U in mineral P-fertilisers
- Supporting the development and improvement of technologies for P-recovery

BALTIC MANURE
BUSINESS OPPORTUNITIES

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Thank you for your attention!

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